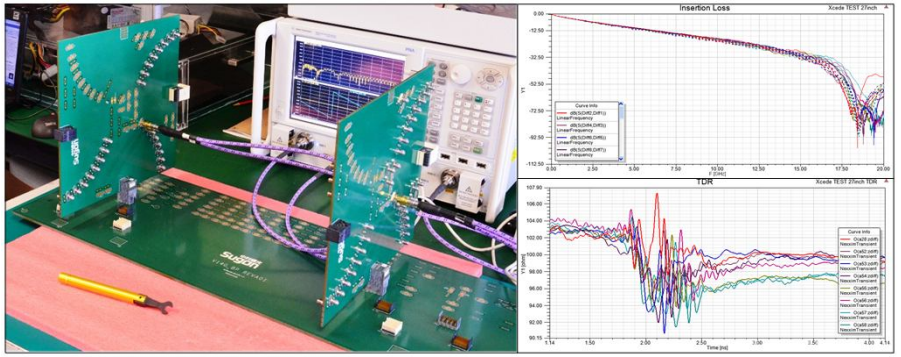
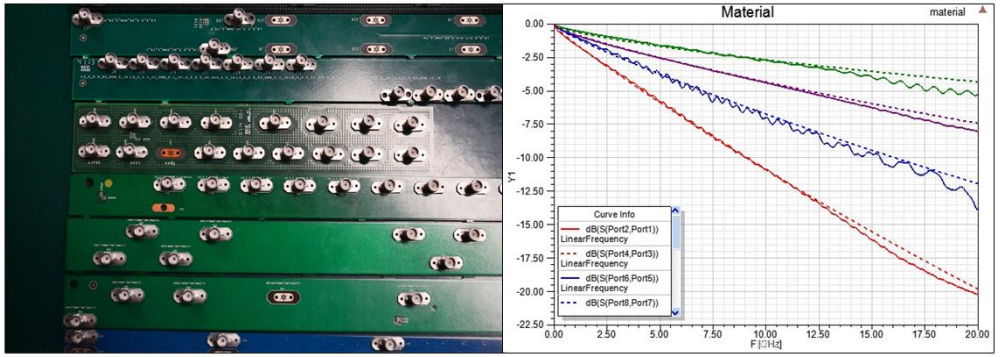
EDI CON 2019
Electronic Design Innovation Conference
电子设计创新大会
April 1-3, 2019
China National Convention Center
Beijing, China

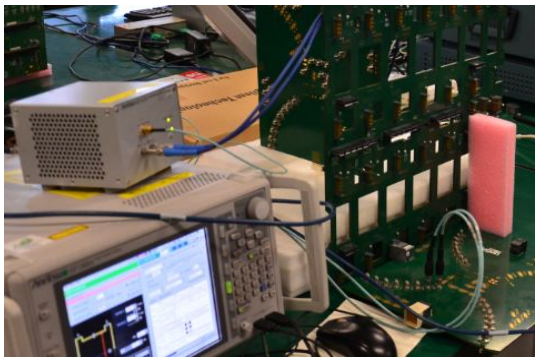
Asymmetric Structure and fiberweave effect impact to high speed Signal

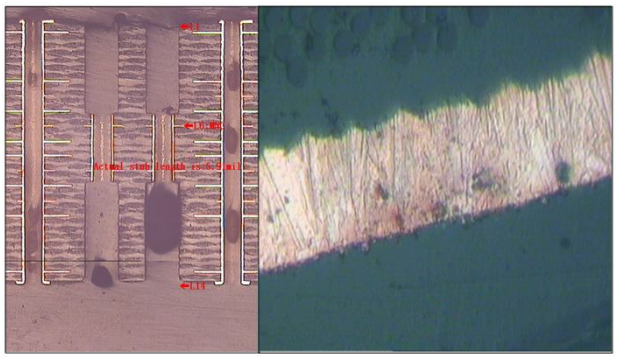
Sugon SI Team: 赵振伟

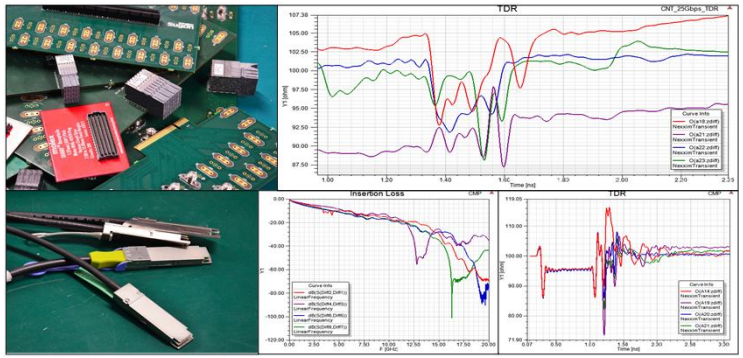
Introduction of Sugon SI Lab











Agenda

Assymetric Structure	Skew Simulation&Mathematic	FiberWeave
[redacted]	[redacted]	[redacted]

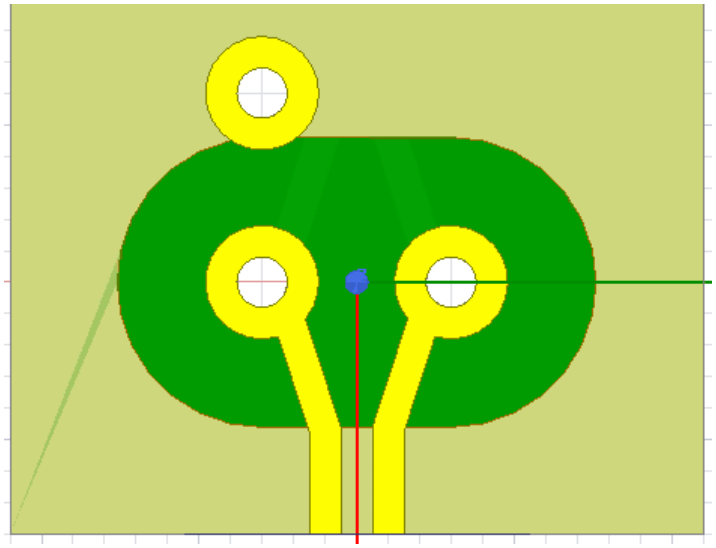
01

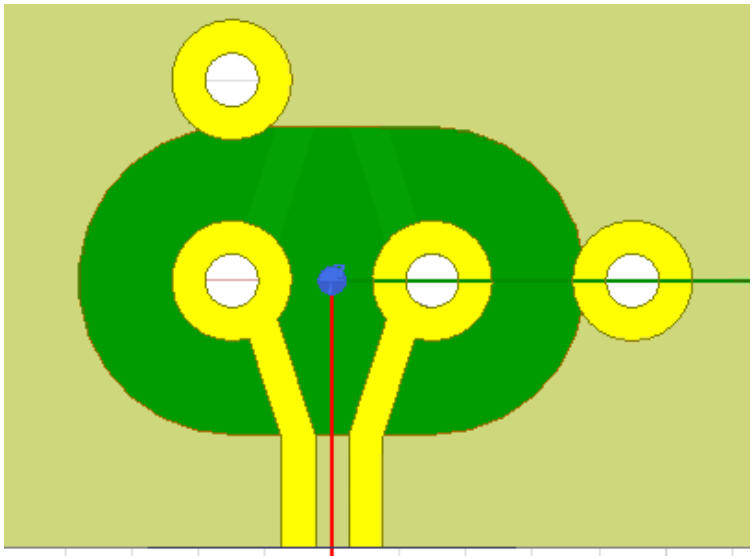
CHAPTER

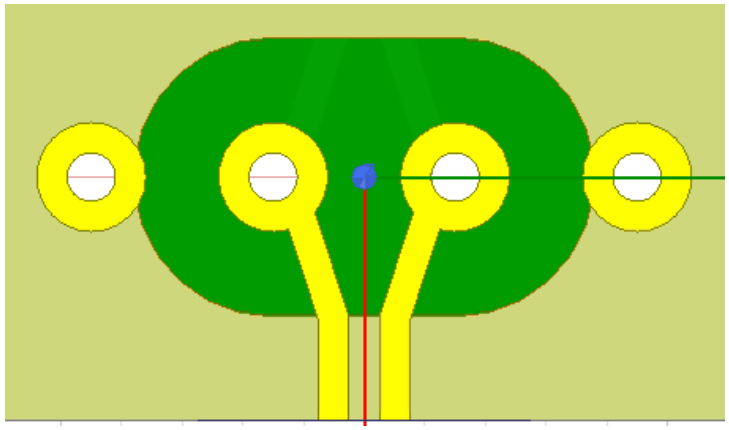
Layout&Manufacture Sturcture

- Differential Via Structure
- Skew occur compensation position
- 45 angle or Arc bend
- Compensation and Straight Line
- Backdrill Precision

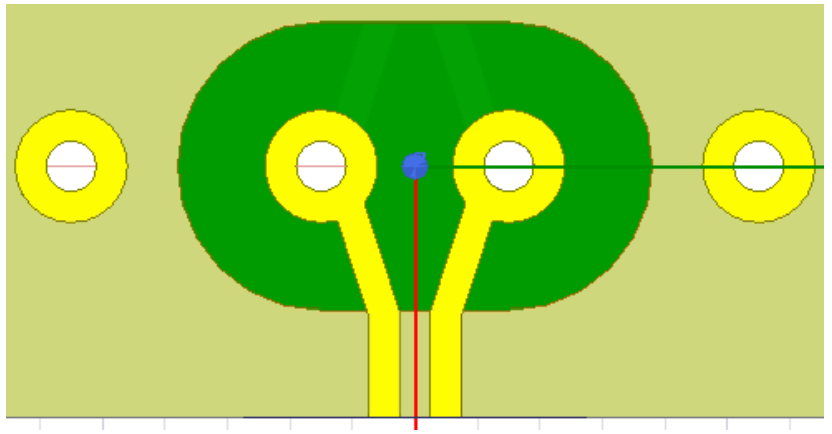
Differential Signal and GND Structure





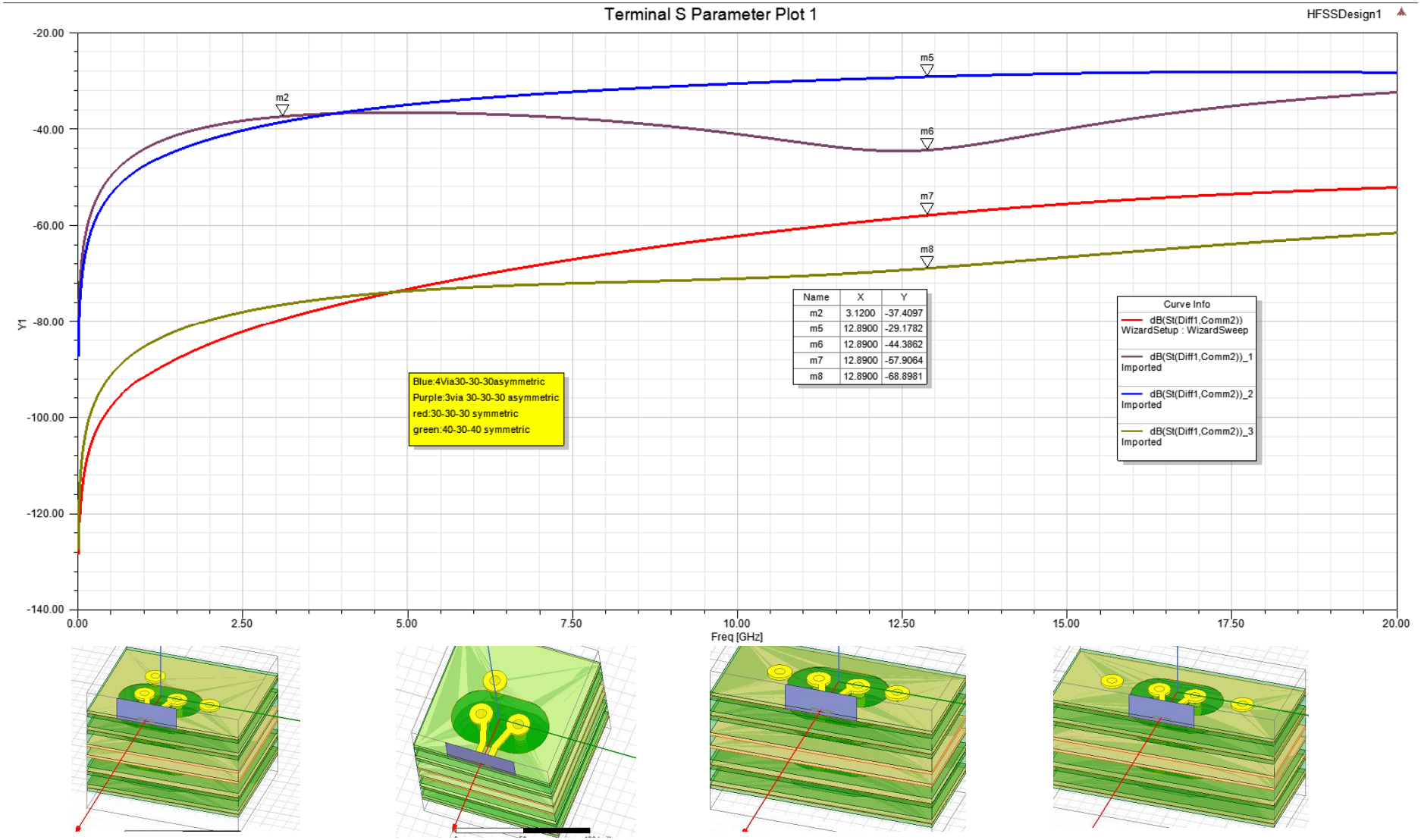


30-30-30

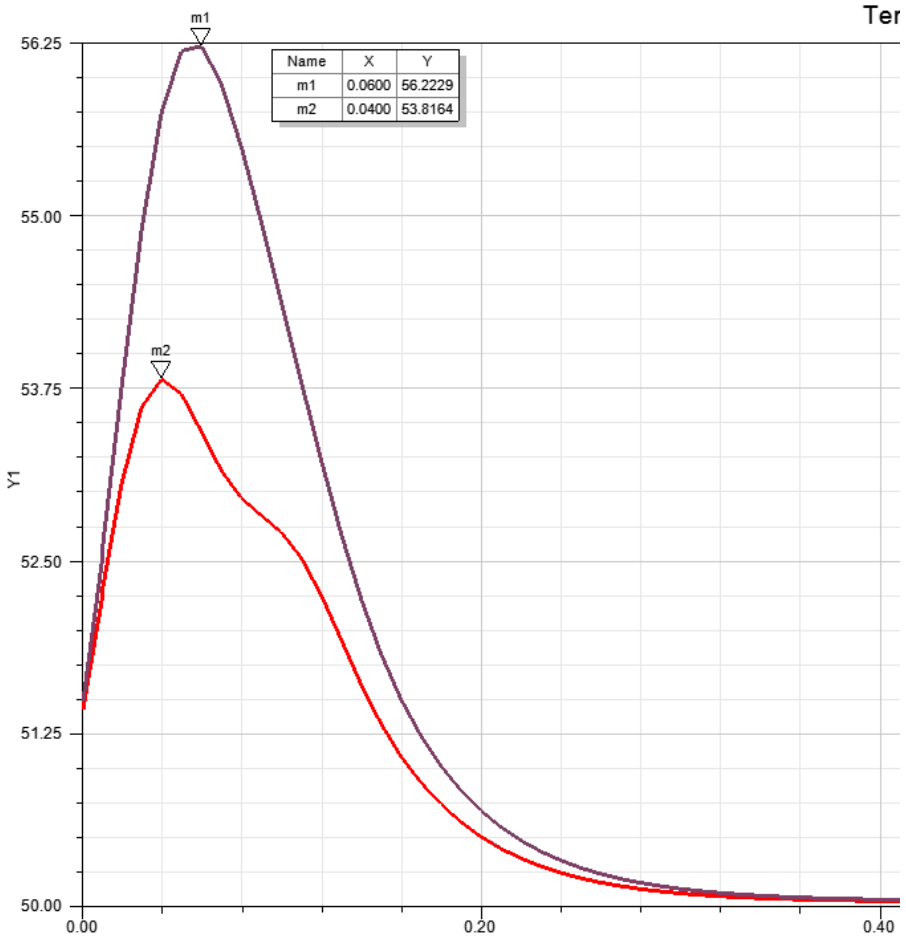


40-30-40

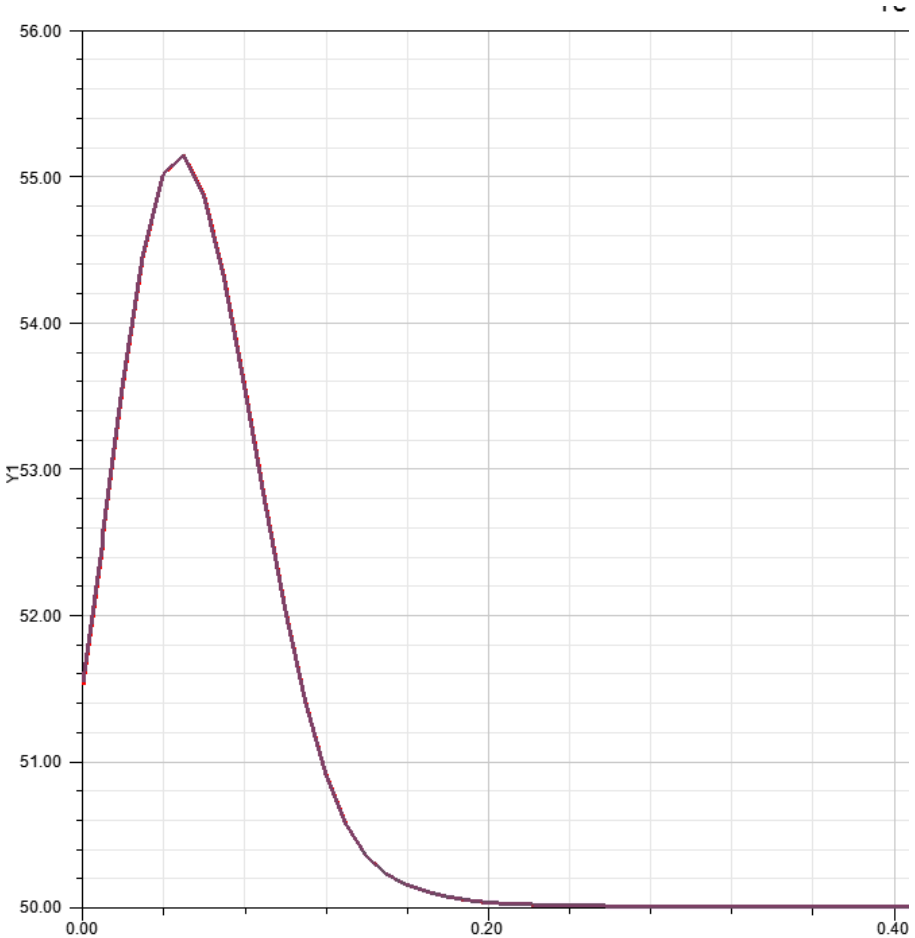
Differential Signal and GND Structure



TDR and skew

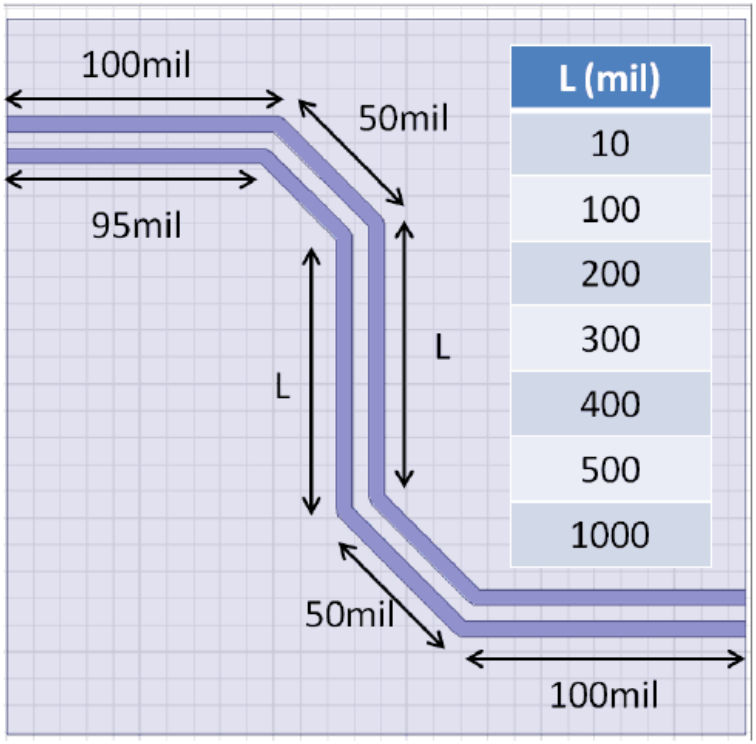


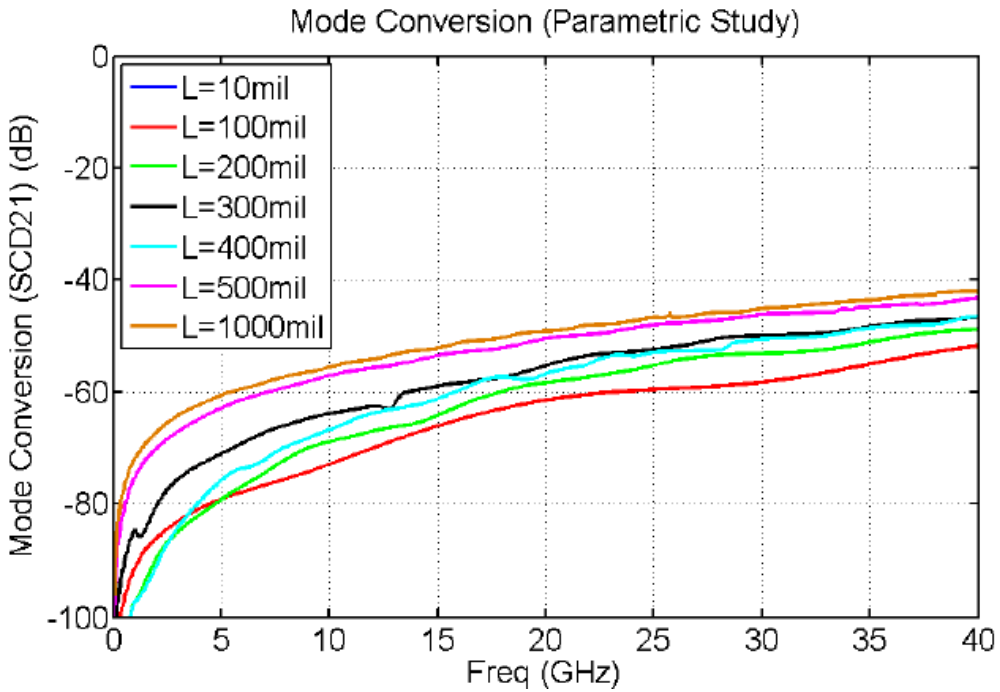
Asymmetric



Symmetric

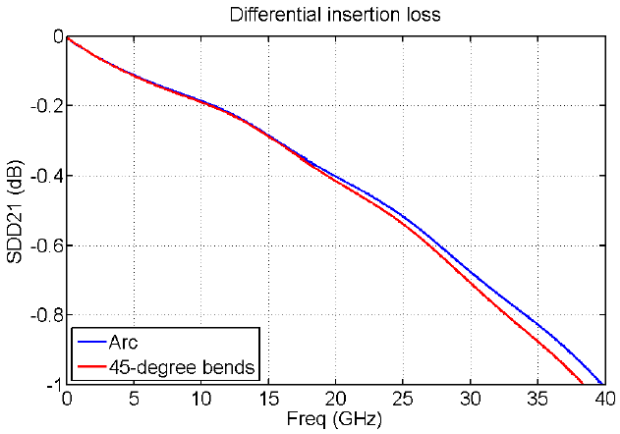
Line Skew Compensation

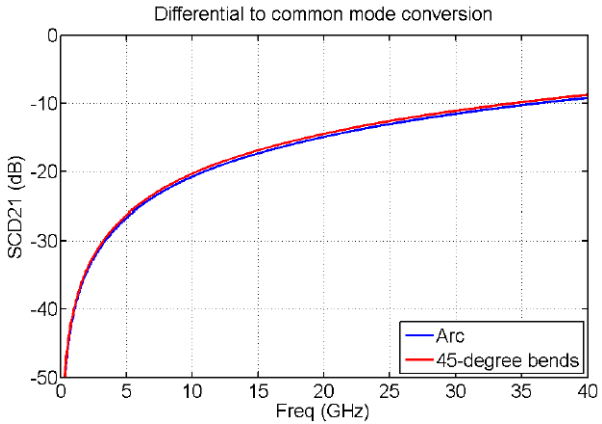


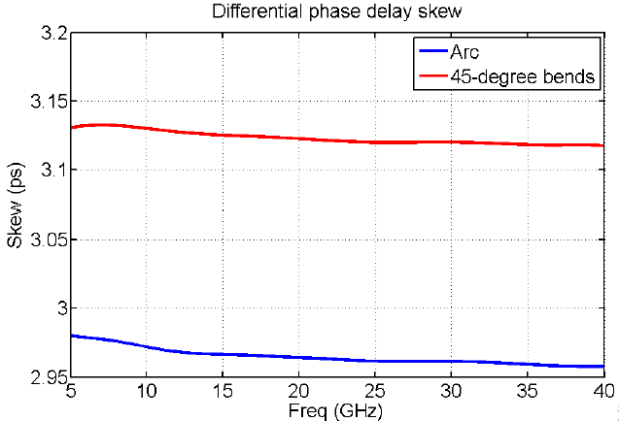


Arc and 45 degree bend

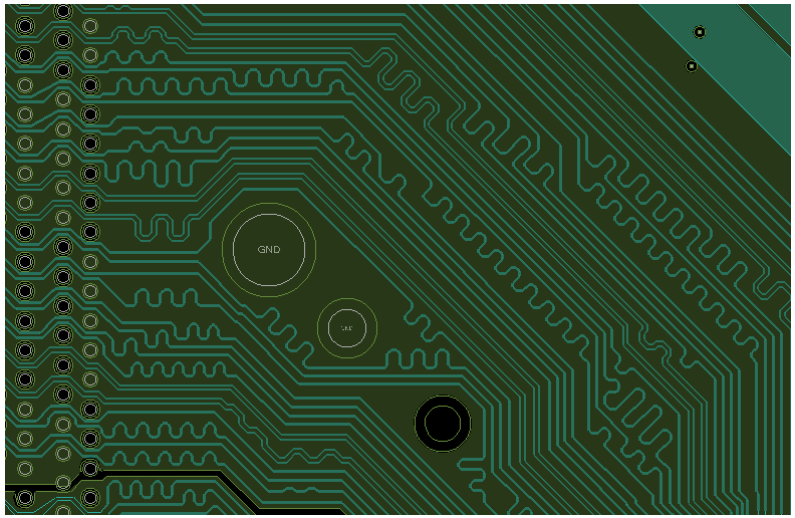
Horizon：100mil
Vertical：100mil
Radius： 30mil
Inner Line and Outer Line difference equal to16mil







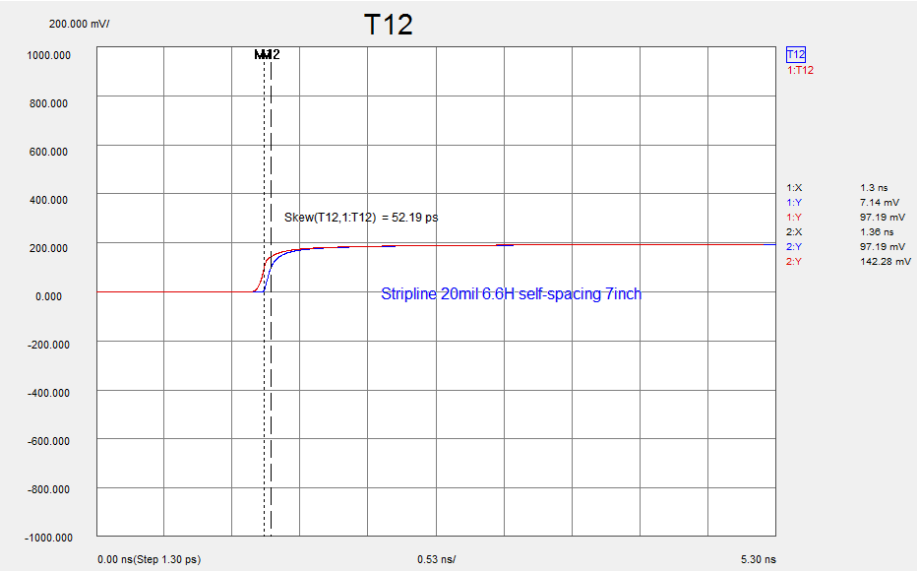
Length Compensation Struction

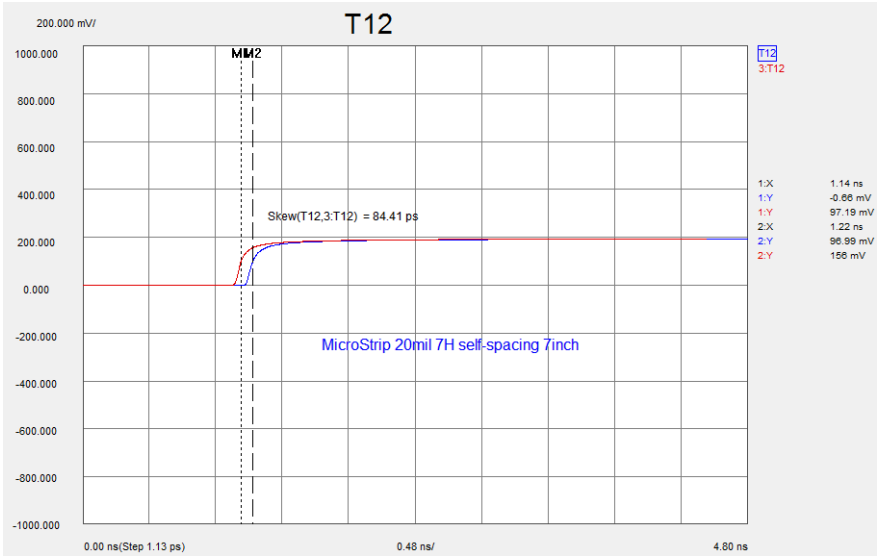


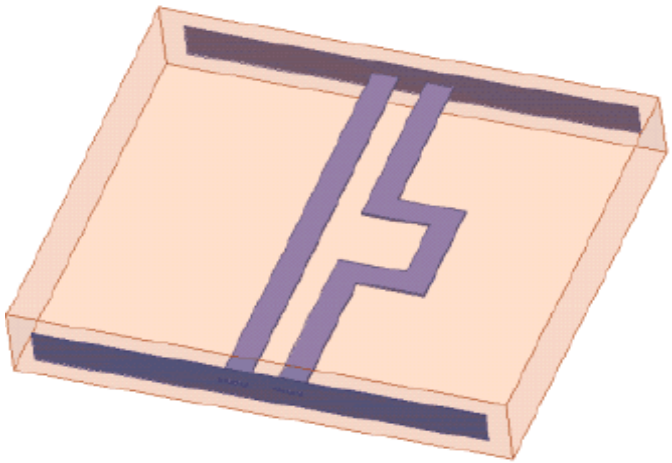
DIMM Memory Routing

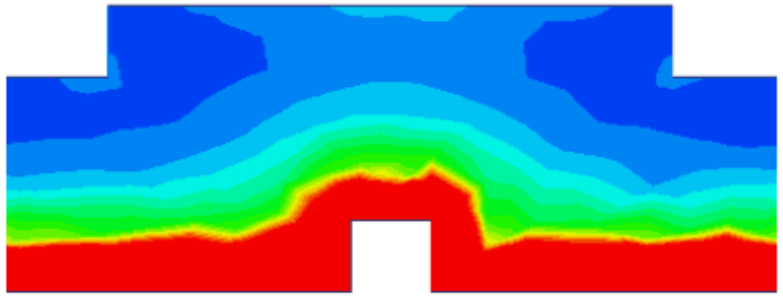
测量线长度为7inch，走折线或者单根直线；Stripline Self-Spacing is 6H；表层为7H，间距都是20mil

Result

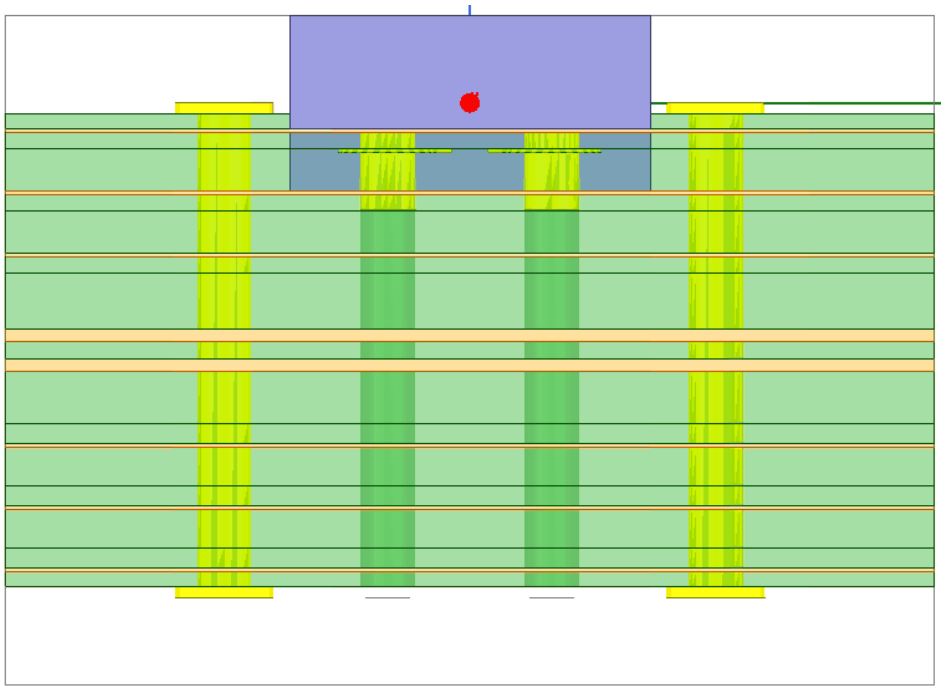

T12
200.000 mV/
1000.000
800.000
600.000
400.000
200.000
0.000
-200.000
-400.000
-600.000
-800.000
-1000.000
M2
Skew(T12,1:T12) = 52.19 ps
Stripline 20mil 6.6H self-spacing 7inch
T12
1:T12
1:X 1.3 ns
1:Y 7.14 mV
1:Y 97.19 mV
2:X 1.36 ns
2:Y 97.19 mV
2:Y 142.28 mV
0.00 ns(Step 1.30 ps)
0.53 ns/
5.30 ns


T12
200.000 mV/
1000.000
800.000
600.000
400.000
200.000
0.000
-200.000
-400.000
-600.000
-800.000
-1000.000
M2
Skew(T12,3:T12) = 84.41 ps
MicroStrip 20mil 7H self-spacing 7inch
T12
3:T12
1:X 1.14 ns
1:Y -0.66 mV
1:Y 97.19 mV
2:X 1.22 ns
2:Y 96.99 mV
2:Y 156 mV
0.00 ns(Step 1.13 ps)
0.48 ns/
4.80 ns

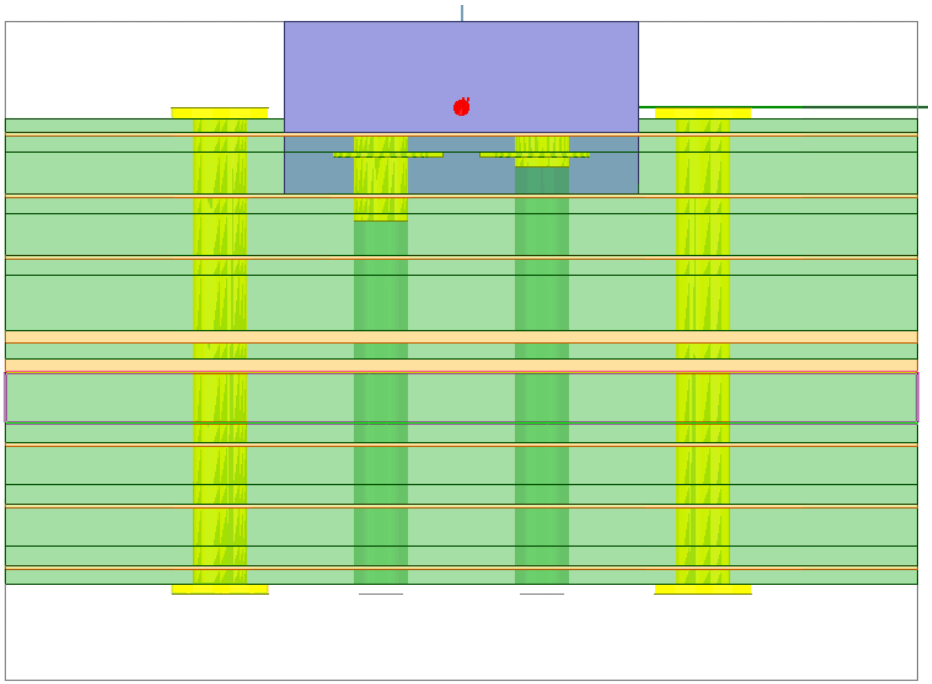




Differential Via Backdrill Precision

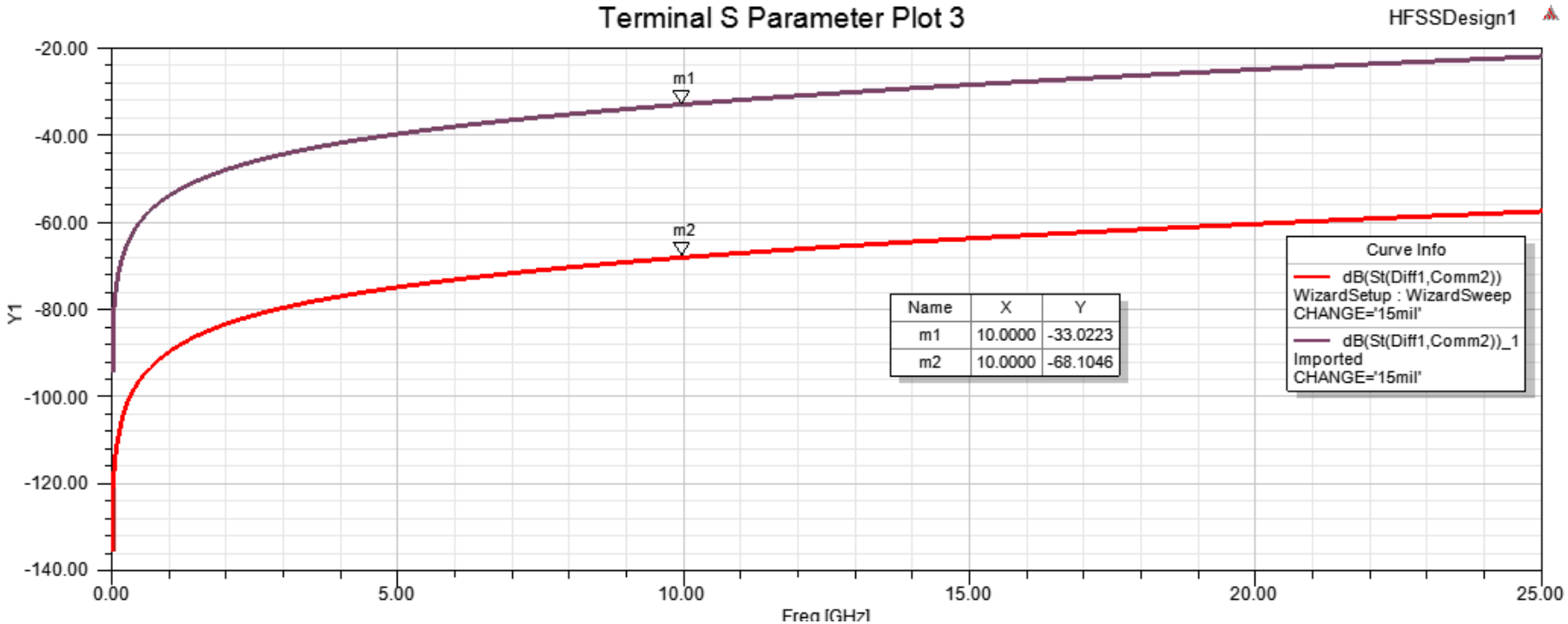


P/N Stub:12mil



P Stub:12mil
N Stub:2mil

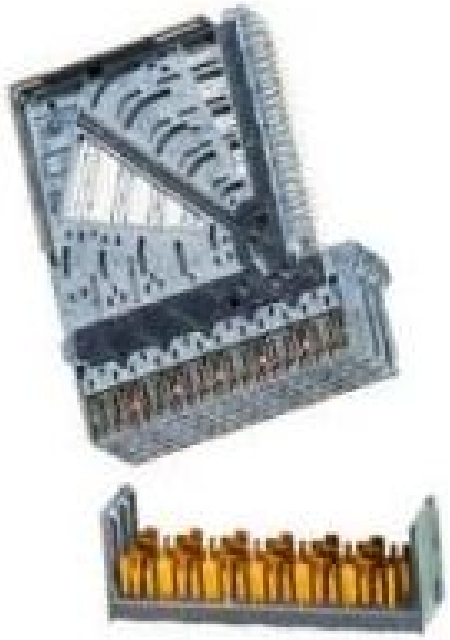
BackDrill difference Mode Conversion



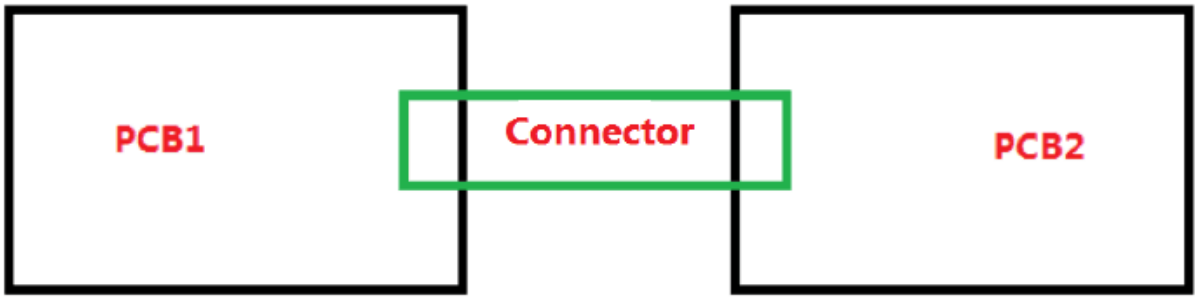
Red：P/N Stub 12mil

Purple：P Stub 12mil
N Stub 2mil

Connector P and N Skew



Differential Pair	Intra-Pair Skew^2 (pS)
AB3	2
AB4	3
CD3	1
CD4	1
EF3	-3
EF4	-4
GH3	-4
GH4	-3



How to ensure PCB1 and PCB2 Skew nearly to zero?

Cable Scd21

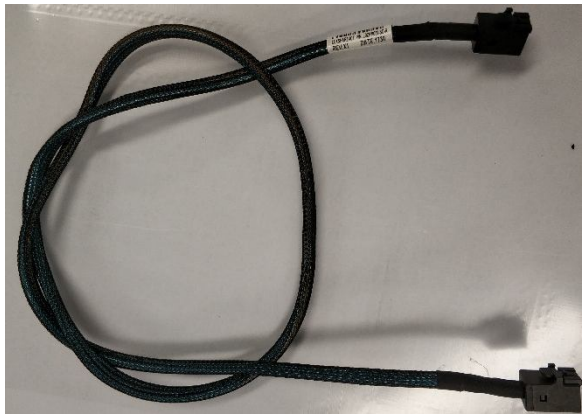


Figure 97 shows the passive TxRx connection $|S_{DD22}|$, $|S_{CD22}|$, $|S_{CD21}|$, and NEXT limits defined in table 26.

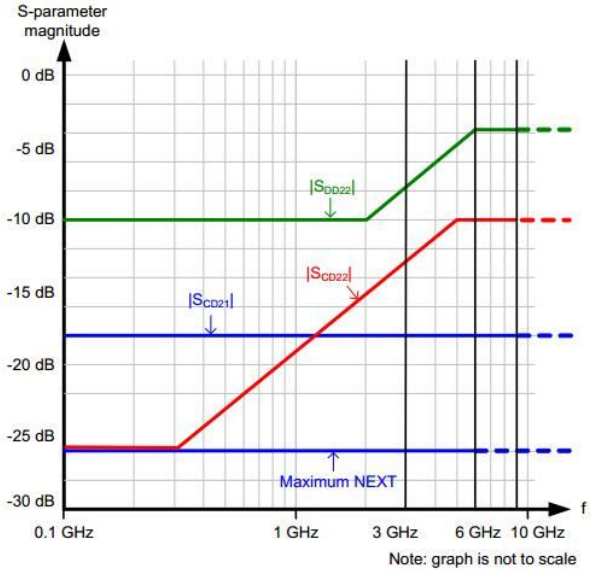
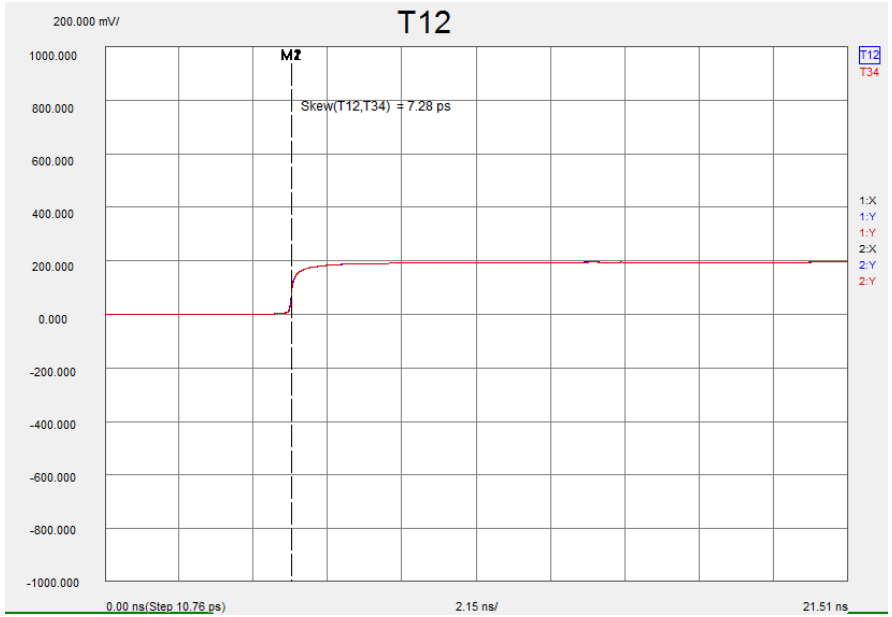
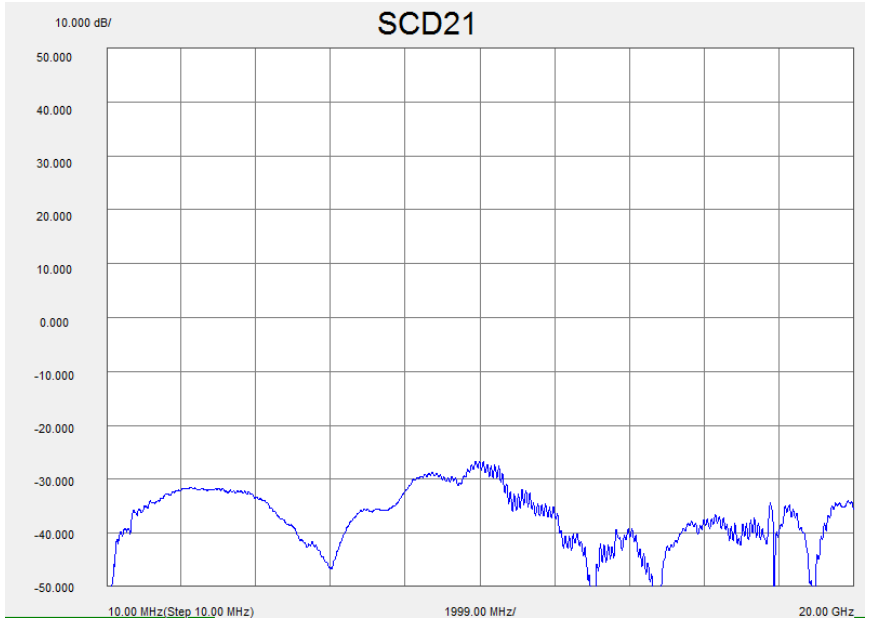


Figure 97 — Passive TxRx connection $|S_{DD22}|$, $|S_{CD22}|$, $|S_{CD21}|$, and NEXT limits





02

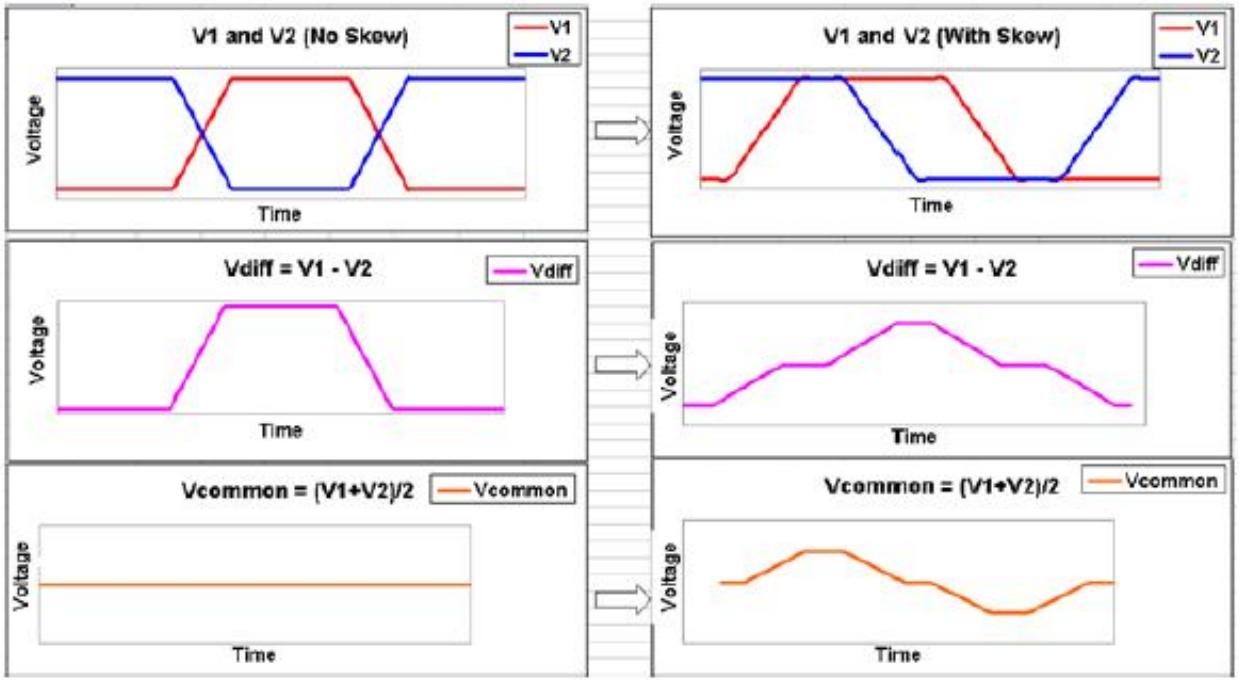
CHAPTER

Skew Simulation&Mathematic

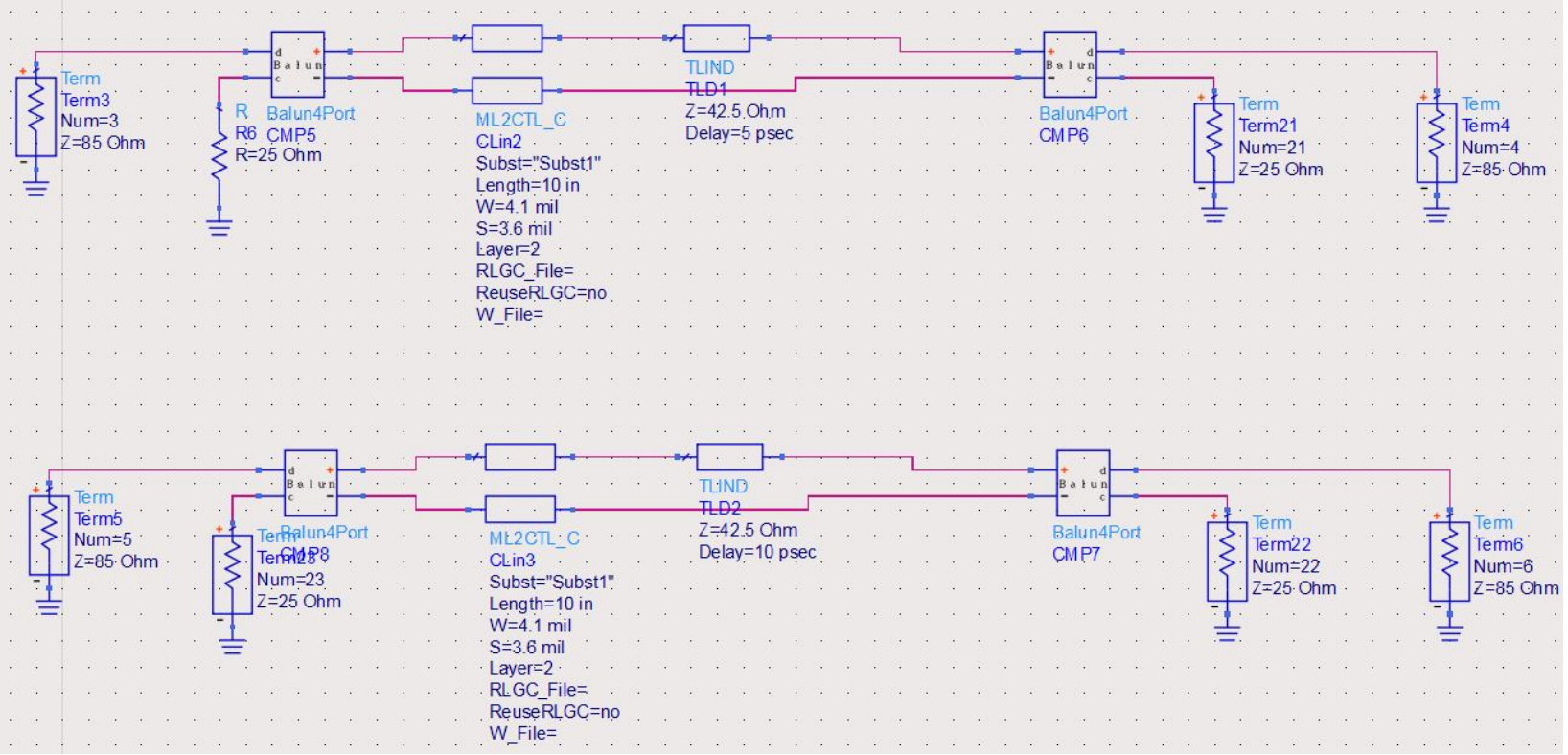
- **Simulation for Time Domain**
- **Simulation in time domain eye diagram**
- **Mathematic Formula**

Skew Definition

- ***"Differential skew" refers to the time difference between the two single-ended signals in a differential pair.***



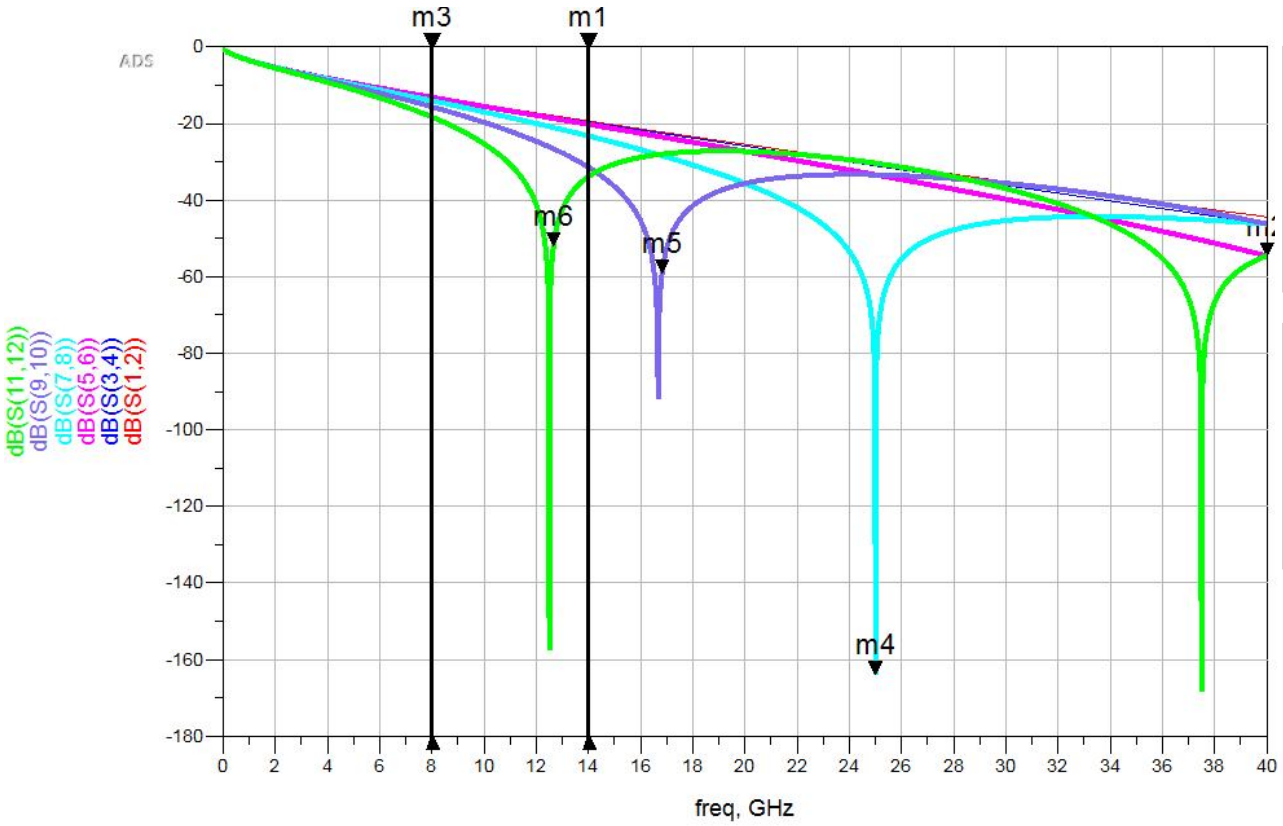
Skew impact on FD



Skew
0ps
5ps
10ps
20ps
30ps
40ps

Length：10inch
Material：M6G

Sdd21 Insertion loss



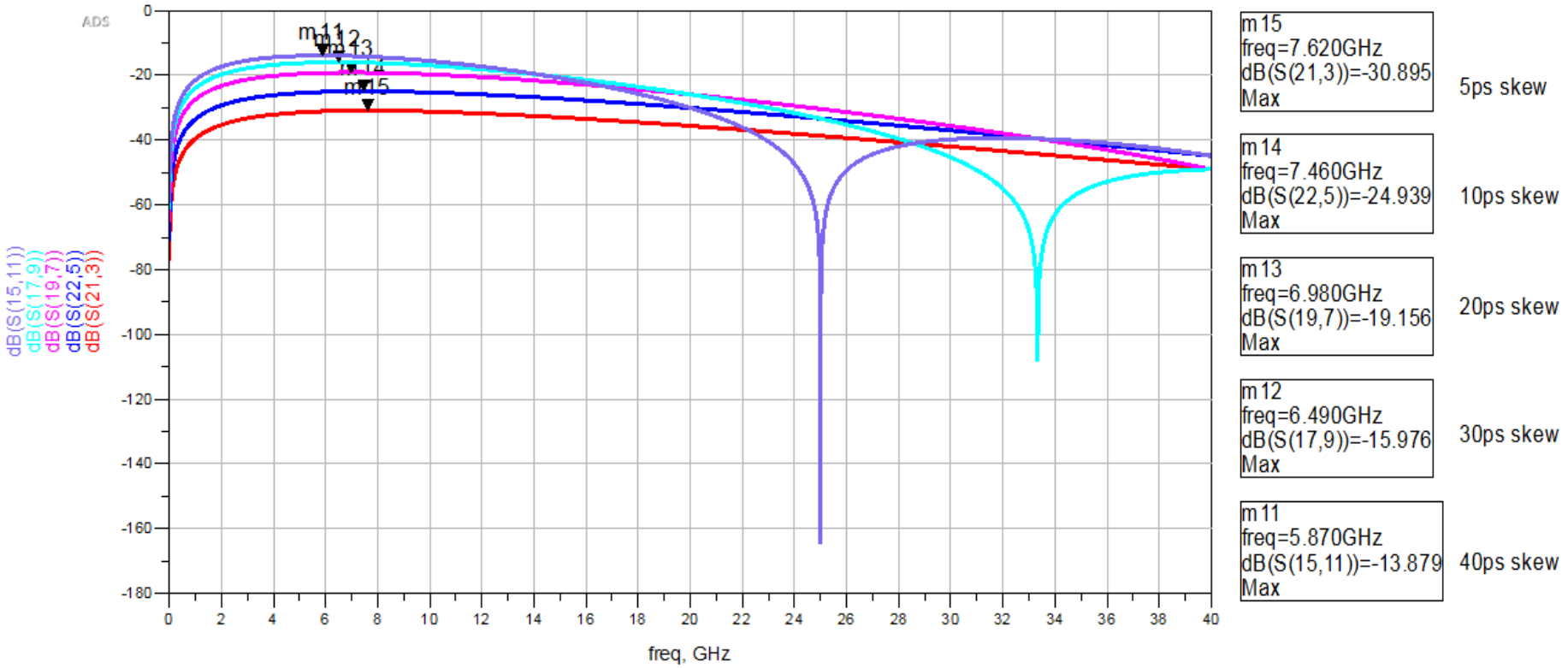
m3
freq=8.000GHz
dB(S(1,2))=-12.872
dB(S(3,4))=-12.940
dB(S(5,6))=-13.149
dB(S(7,8))=-14.019
dB(S(9,10))=-15.615
dB(S(11,12))=-18.285

S(1,2) 0ps skew
S(3,4) 5ps skew
S(5,6) 10ps skew
S(7,8) 20ps skew
S(9,10) 30ps skew
S(11,12) 40ps skew

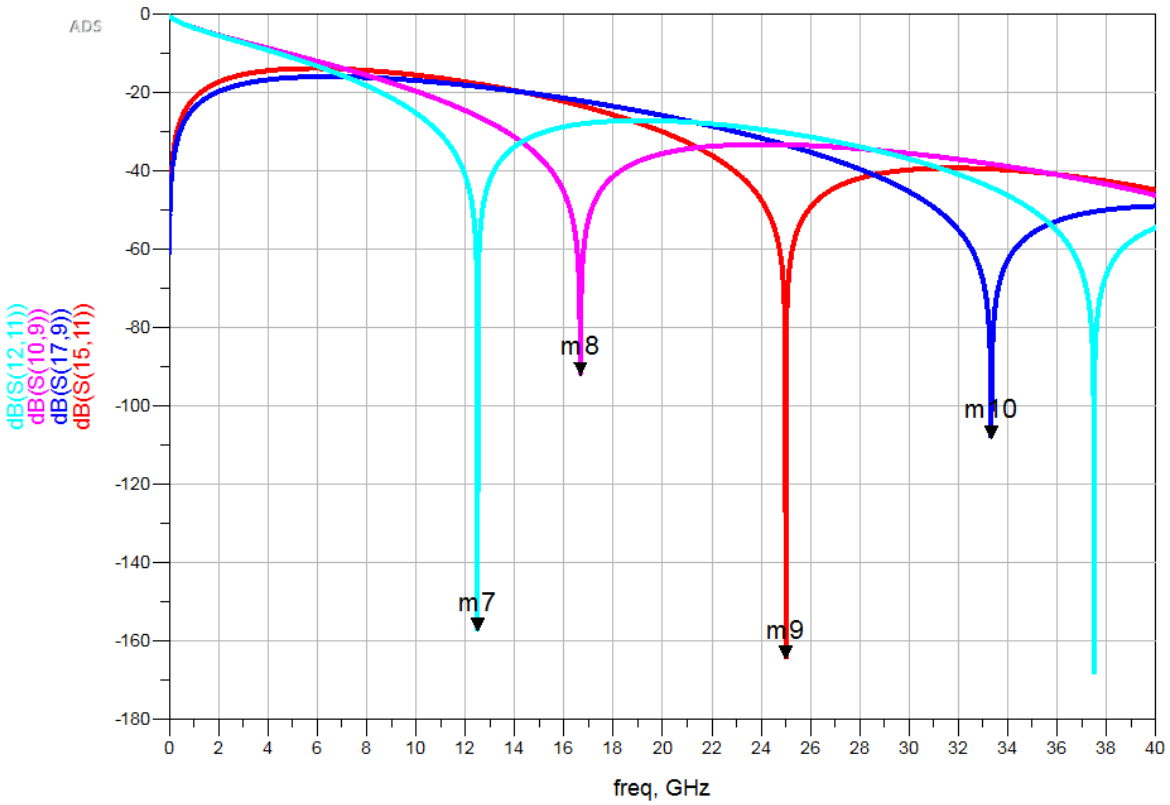
m1
freq=14.00GHz
dB(S(1,2))=-19.322
dB(S(3,4))=-19.534
dB(S(5,6))=-20.192
dB(S(7,8))=-23.231
dB(S(9,10))=-31.398
dB(S(11,12))=-33.858

S(1,2) 0ps skew
S(3,4) 5ps skew
S(5,6) 10ps skew
S(7,8) 20ps skew
S(9,10) 30ps skew
S(11,12) 40ps skew

Scd21 Diff to Comm



Resoance Frequency

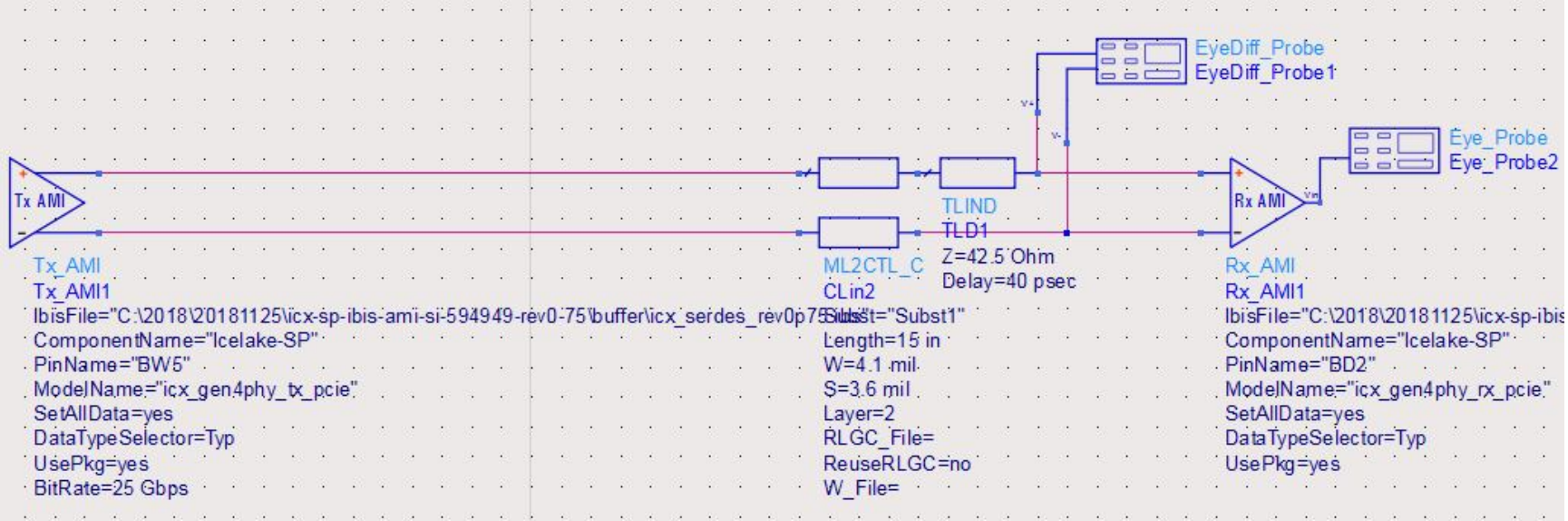


Scd21	m10 freq=33.33GHz dB(S(17,9))=-108.311	30ps skew
Scd21	m9 freq=25.00GHz dB(S(15,11))=-164.604	40ps skew
Sdd21	m8 freq=16.67GHz dB(S(10,9))=-92.113	30ps skew
Sdd21	m7 freq=12.50GHz dB(S(12,11))=-157.530	40ps skew

$$Sdd21_{re}(f) = \frac{500}{t_{skew}}\ (ps)$$

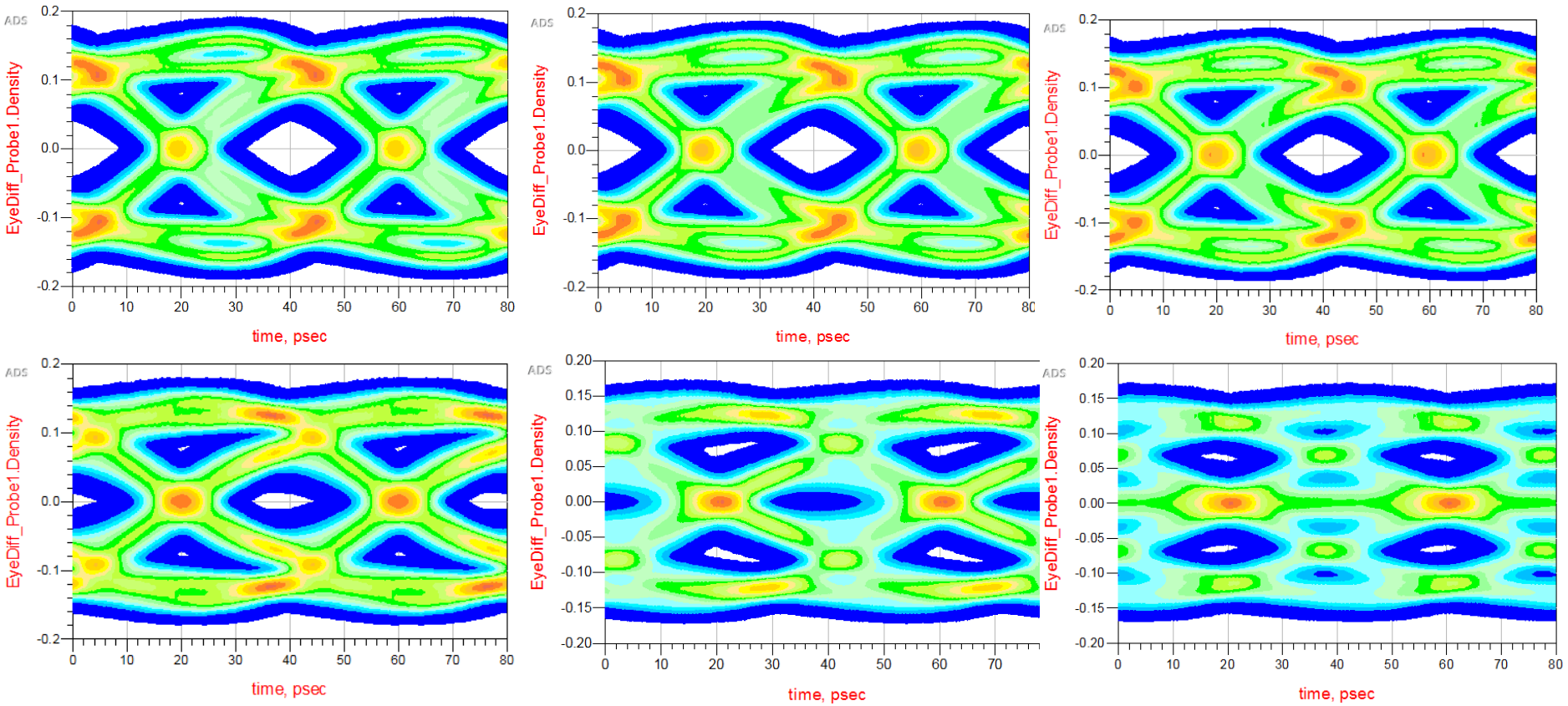
$$Scd21_{re}(f) = \frac{1000}{t_{skew}}\ (ps)$$

AMI Eye



Skew	0ps	5ps	10ps	20ps	30ps	40ps
%UI	0UI	0.125UI	0.25UI	0.5UI	0.75UI	1UI

Eye Diagram



Skew Formula

$$S_{dd12} = \frac{S_{13} - S_{14} - S_{23} + S_{24}}{2}$$

$$S_{dd12} = \frac{|S_{13}|e^{j\theta_{13}} + |S_{24}|e^{j\theta_{24}} - |S_{14}|e^{j\theta_{14}} - |S_{23}|e^{j\theta_{23}}}{2}$$

$$S_{dd12} = \frac{|IL|}{2}\left(e^{j\theta_{13}} + e^{j\theta_{24}}\right) - \frac{|X|}{2}\left(e^{j\theta_{14}} + e^{j\theta_{23}}\right)$$

$$S_{dd12} = \frac{|IL|}{2}\left(e^{j\theta_{13}} + e^{j\theta_{24}}\right)$$

$$\theta_{13} = \theta + \frac{\Delta\theta}{2} \text{ and } \theta_{24} = \theta - \frac{\Delta\theta}{2}$$

$$S_{dd12} = |IL|\cos\left(\frac{\Delta\theta}{2}\right)e^{j\theta}$$

$$S_{dd21}=|IL|*\cos(\pi f t_{skew})$$

$$S_{cd21}=|IL|*\sin(\pi f t_{skew})$$

$$Sdd21_{re}(f) = \frac{500}{t_{skew}}\ (ps)$$

$$Scd21_{re}(f) = \frac{1000}{t_{skew}}\ (ps)$$

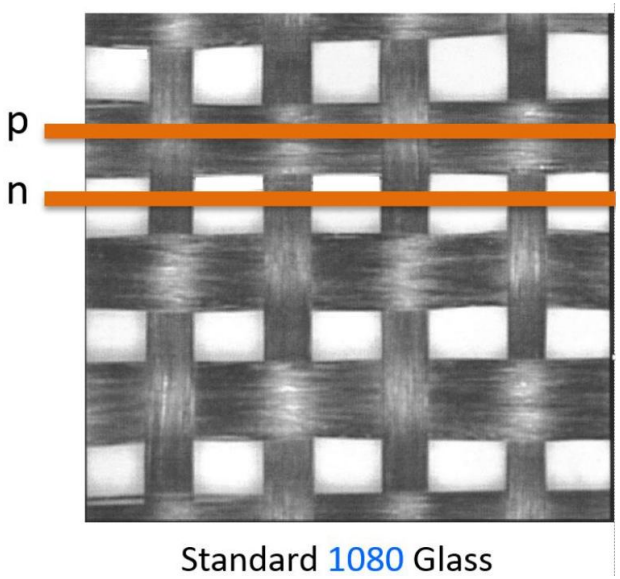
03

CHAPTER

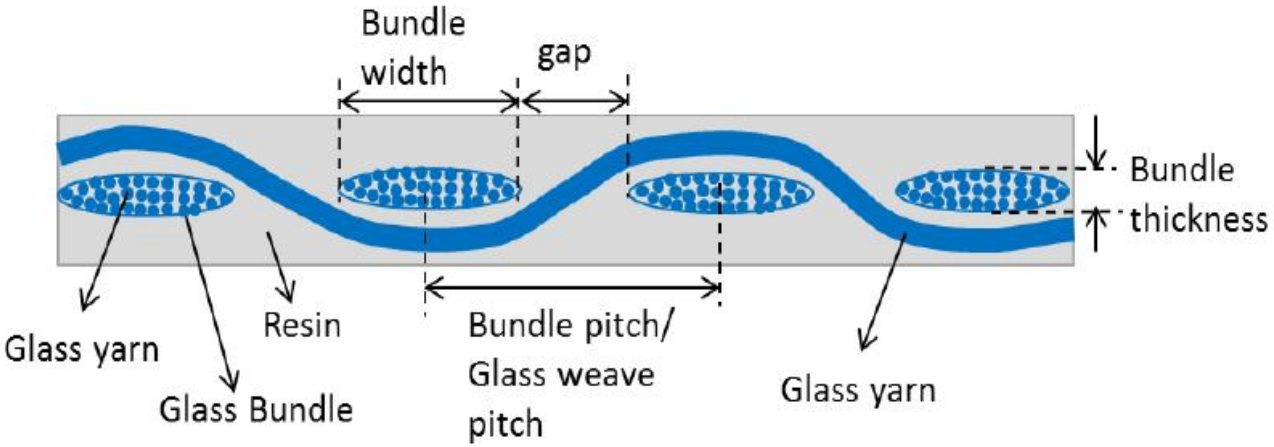
Fiber Weave

- Warp and fill
- How to measure Skew
- Case Share

Fiber Weave



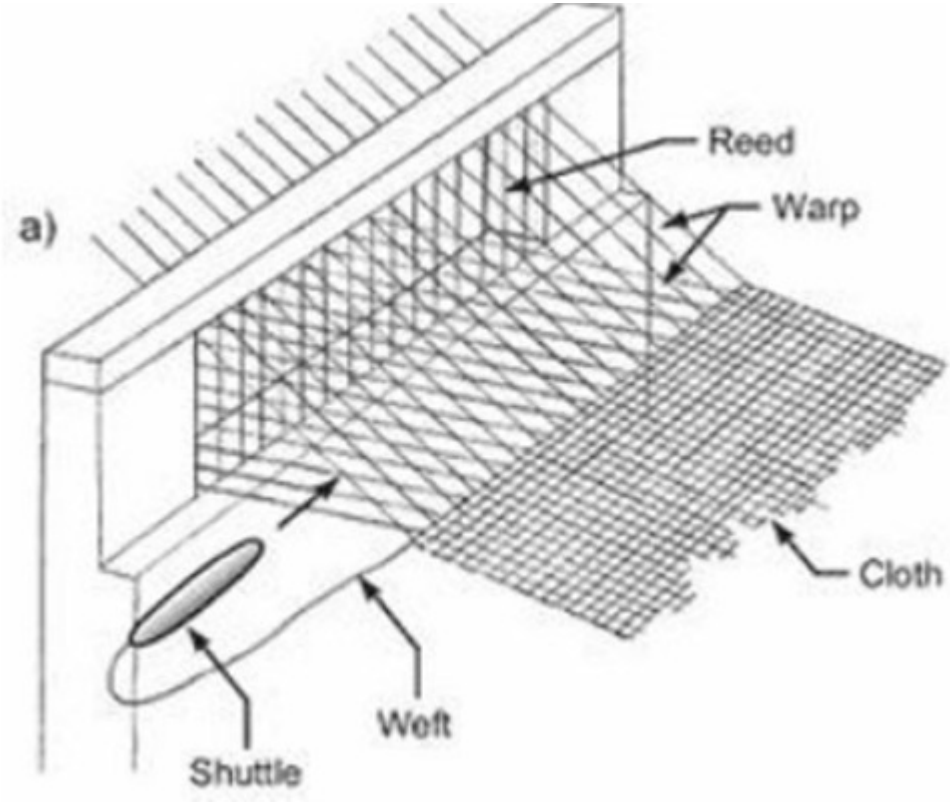
Standard 1080 Glass

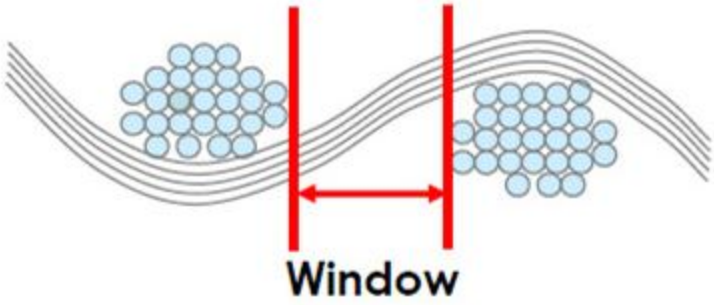


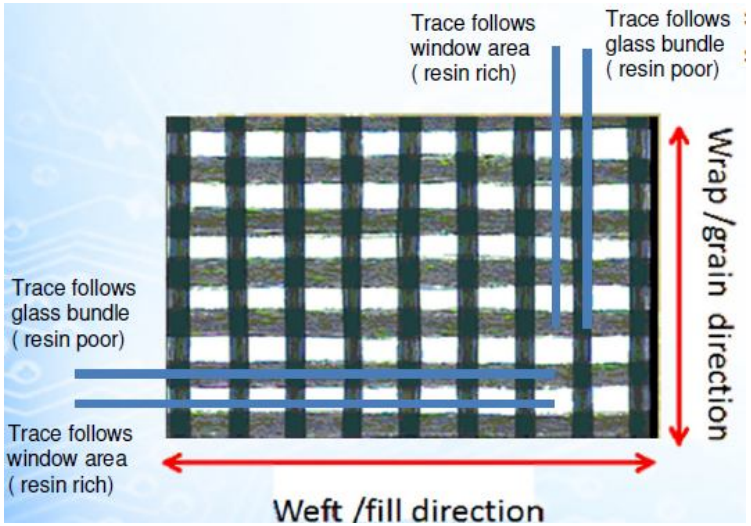
Glass and resin Dk different

Propagation Velocity : $v = \frac{C}{\sqrt{\varepsilon_r}} (m/s)$

Wrap &Fill


a)
Reed
Warp
Cloth
Weft
Shuttle


Window


Trace follows window area (resin rich)
Trace follows glass bundle (resin poor)
Wrap /grain direction
Trace follows glass bundle (resin poor)
Trace follows window area (resin rich)
Weft /fill direction

Different Speed Glass Type

	Style	#106	#1080	#2113	#3313	#2313	#2116	#1501/#1506	#1652	#7628
Normal Spread	Glass Fabric									
	Fabric Count / inch (Fill / Wrap)	56x56	60x47	60x56	60x62	60x64	60x58	46x45	52x52	44x32
	Nominal Thickness of glass (mils)	1.5	2.5	2.9	3.2	3.2	3.8	5.6	4.5	6.8
	Typical Nominal Thickness 1ply (glass + resin) mils	2-3	3.5-4	3.5-4.5	4.0-5.5	4.0-5.5	5.0-6	6.5-7.3	5-6	7.7-9.0

	Style	#1037	#1035	#1067	#1078	#1086
High Spread Glass	Glass Fabric					
	Fabric Count / inch (Fill / Wrap)	70x73	66x68	70x70	54x54	60x60
	Nominal Thickness of glass (mils)	1.2	1.2	1.3	1.7	2
	Typical Nominal Thickness 1ply (glass + resin) mils	2-2.5	2-2.5	2.0-2.8	2.8-4.1	3-3.8

Is Spread Glass can totally solve skew?

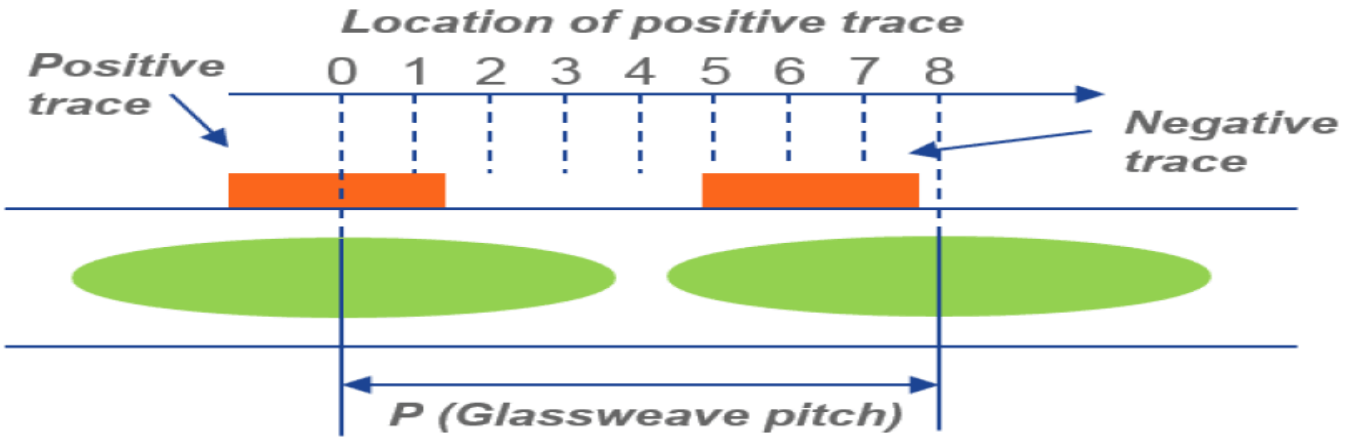
Fiber Character

Glass	pitch	bundle	window	pitch	bundle	Window
1035	15.2	9.0-9.5	5.7-6.2	14.7	14.2-14.7	0-0.5
1067	14.3	9.2-9.5	4.8-5.1	14.3	13.8-14.4	0-0.5
1078	18.5	12.3-12.8	5.7-6.2	18.5	18.0-18.5	0-0.5
3313	16.4	12.0-12.5	4.2-4.7	16.1	13.7-14.2	1.9-2.4
2116	16.7	13.2-13.7	3.0-3.5	17.2	15.1-15.5	1.7-2.1
1080	16.7	12.0-12.7	4.0-4.7	21.3	14.5-15.2	6.1-6.8
1086	16.7			16.7		

Warp

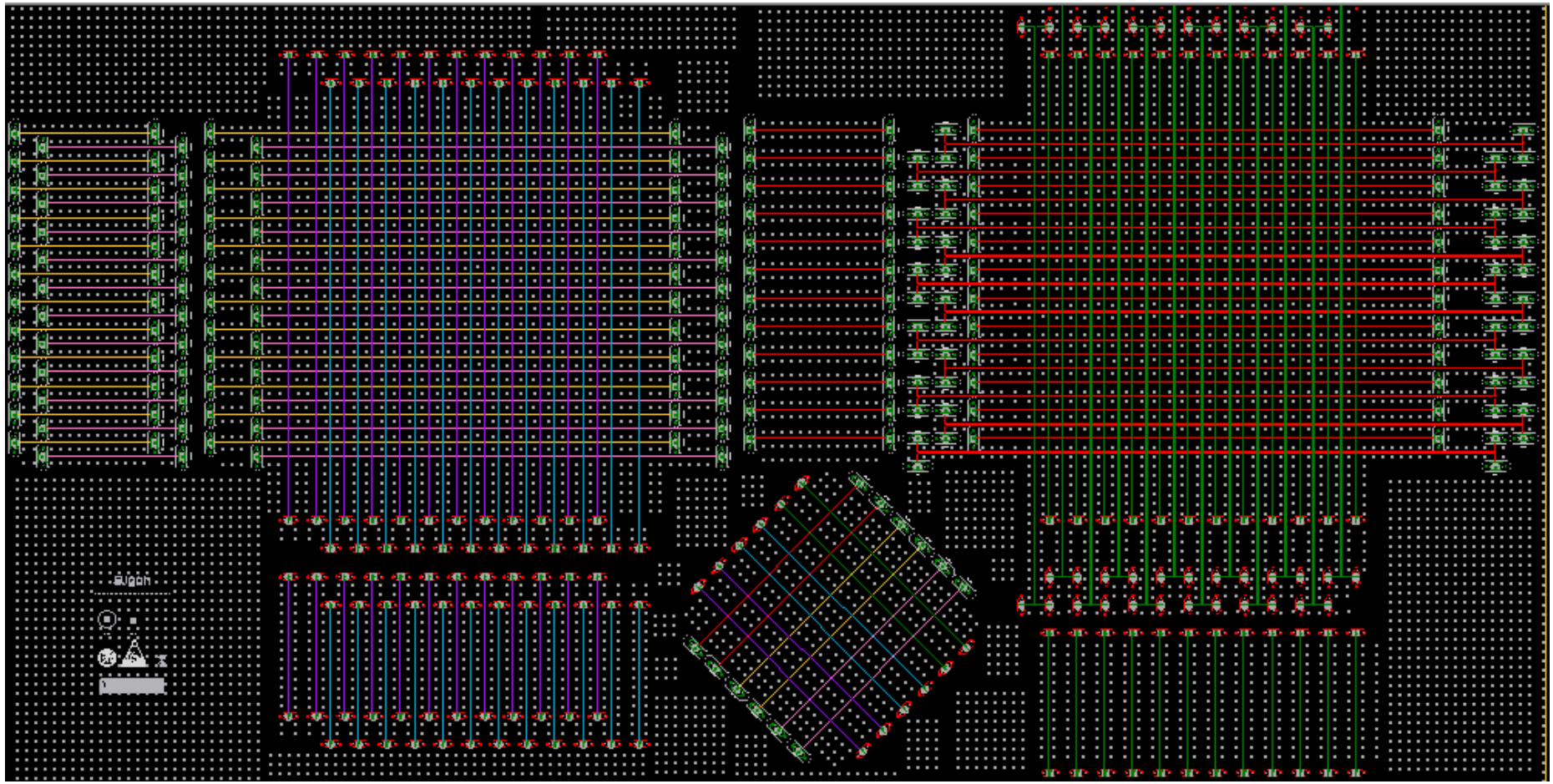
Fill Weft

Design Idea to hack the maximum skew in one board



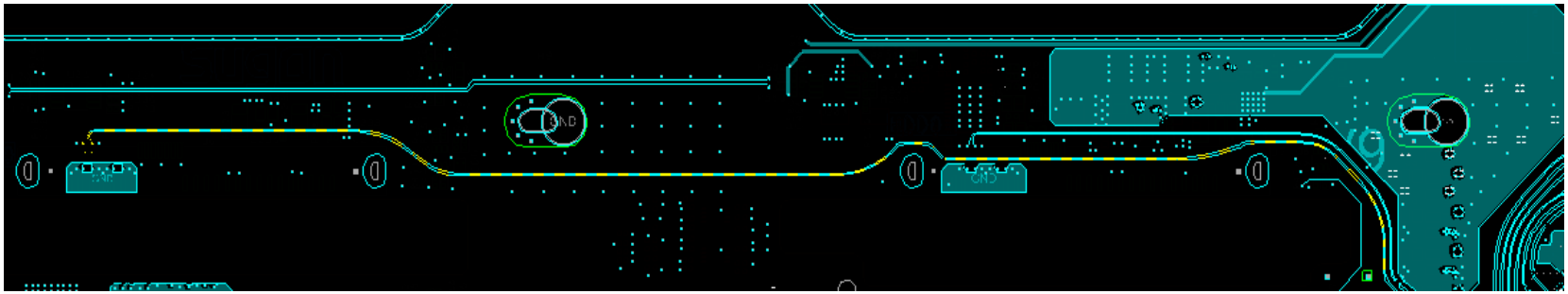
Line1	0		1080Warp(16.7)			1080Fill(21.3)
Line2	603.2	0	0	0	0	0
Line3	603.2	603.2	2	598.4	598.4	2
Line4	603.2	1206.4	4	598.4	1196.8	4
Line5	603.2	1809.6	6	598.4	1795.2	6
Line6	603.2	2412.8	8	598.4	2393.6	8
Line7	603.2	3016	10	598.4	2992	10
Line8	603.2	3619.2	12	598.4	3590.4	12
Line9	603.2	4222.4	14	598.4	4188.8	14
Line10	603.2	4825.6	16	598.4	4787.2	16
Line11	603.2	5428.8	1.3	598.4	5385.6	18
Line12	603.2	6032	3.3	598.4	5984	20
	601.2			596.4		

Skew TestBoard

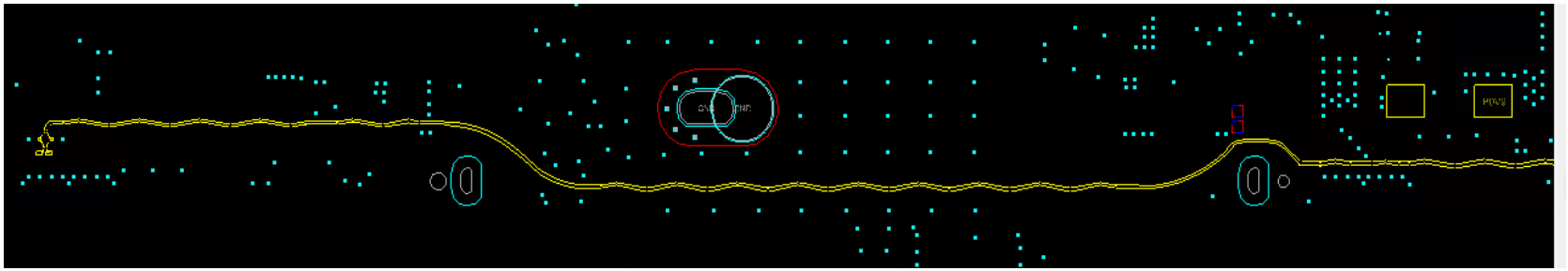


Board Rotate 2,4,6,8,10 degree

SAS 12G BP Channel



First Version



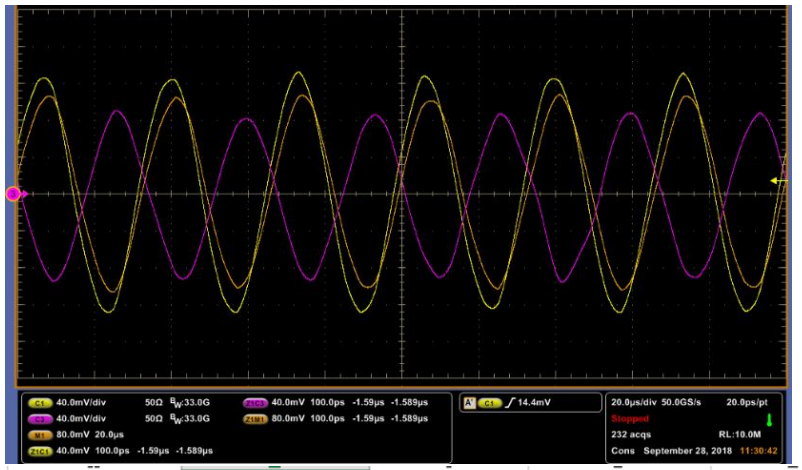
Second Version

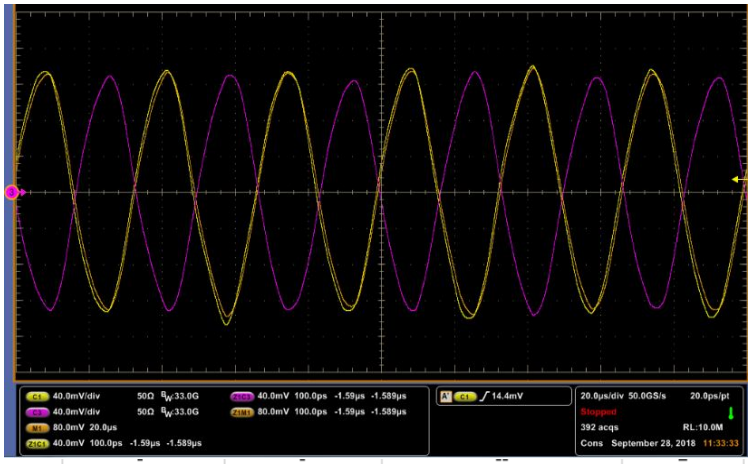
Horizon: 6inch, total 8inch

L2	GND	1oz		1.25
	core	4.2mil(2116*1)		4.20
L3	SIGNAL	1oz		1.25
	prepreg	2116+7628	2116 55% 7628 43%	11.48
L4	GND	1oz		1.25

Stackup

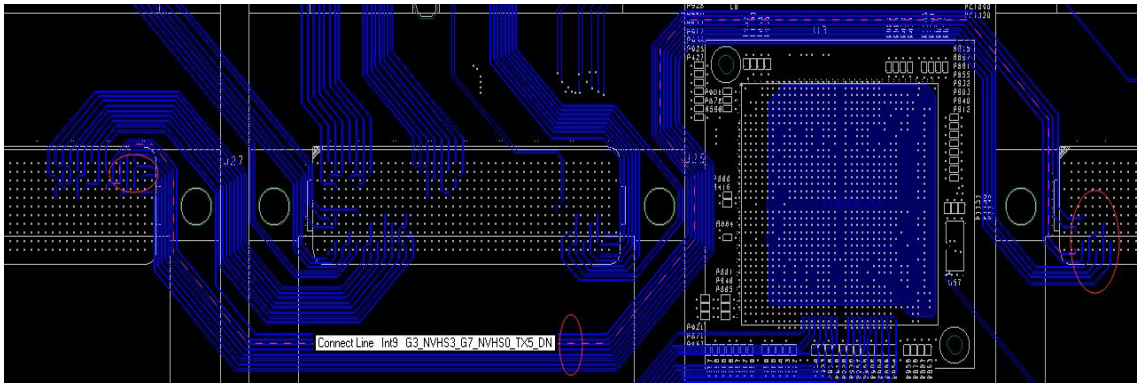
Result Compare

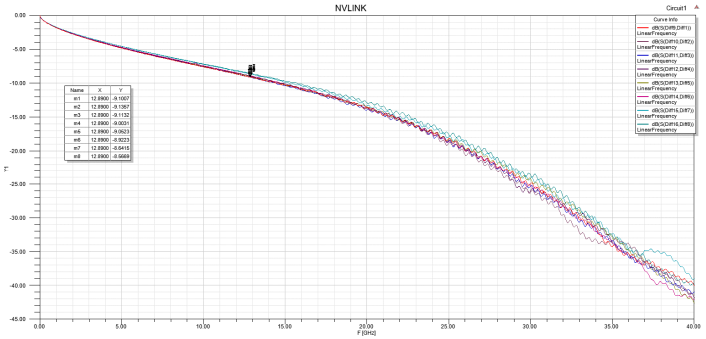




SAS 12G	Eye Width	Eye Height	RJ	DJ	TJ	Skew	AC Common mode	Test Pattern
Spec	**≥70 Ps**	**≥90 mV**	**≤1.5 Ps**	**≤16 Ps**	**≤32 Ps**	**≤10 Ps**	**≤100 mV**	D10.2
Phy4_HDD00	75.484ps	367.18mV	572.34fs	3.5978ps	9.6920ps	16.516ps	92.640mV	D10.2
Phy4_HDD00	75.835ps	383.82mV	552.60fs	3.5664ps	9.5932ps	2.9302ps	29.040mV	D10.2

One Type of 25G Serdes Link



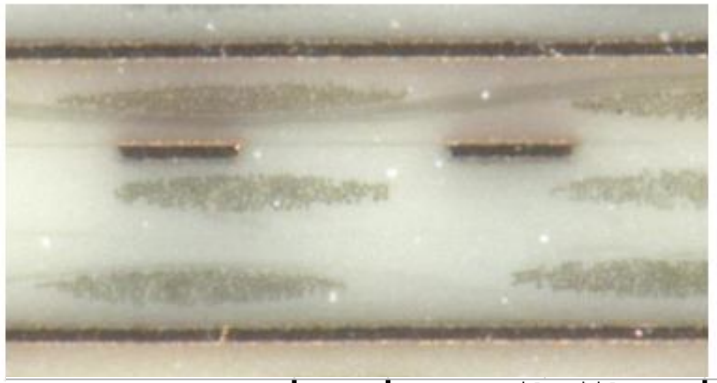


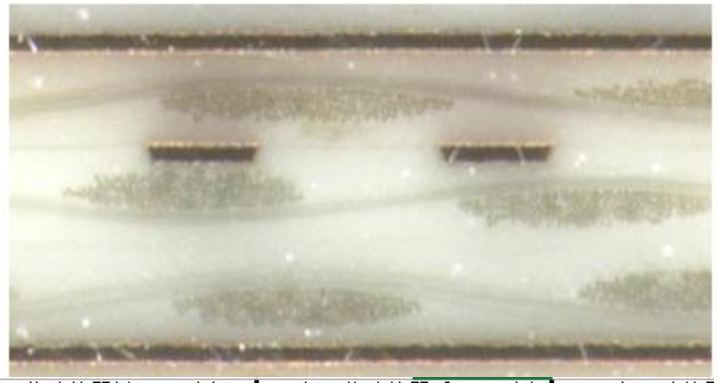
13	1oz		1oz			H-VLP
	PP		PP(1078(RC75%)X1)	4.01	EM-891	
14	1/2oz		1/2oz			H-VLP
	CORE		CORE(1086X1)(rc59%)	3.00	EM-891	
15	1/2oz		1/2oz			H-VLP
	PP		PP(1078(RC73%)X1)	3.74	EM-891	
16	1/2oz		1/2oz			H-VLP
	CORE		CORE(1086X1)(rc59%)	3.00	EM-891	
17	1/2oz		1/2oz			H-VLP
	PP		PP(1078(RC73%)X1)	3.74	EM-891	
18	1/2oz		1/2oz			H-VLP
	CORE		CORE(1086X1)(rc59%)	3.00	EM-891	
19	1/2oz		1/2oz			H-VLP

Boardsize：14.4X16.7in

WUS panel size	Best Direction for SI
12x24	24" fill direction (long axis)
14x16	16" fill direction (long axis)
14x24	24" fill direction (long axis)
18x16	16" fill direction (short axis)
18x24	24" fill direction (long axis)

Cross-Section

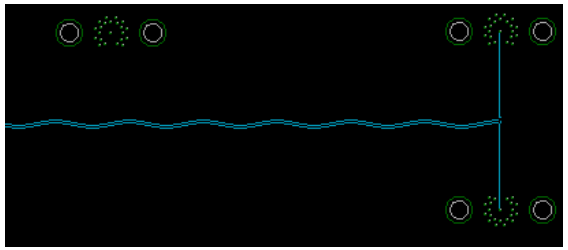




链路	线长	PASS板008底板		fail板（换连接器前）002底板		fail板（换连接器后）002底板		fail板（连接器
		损耗（DB）	skew（ps）	损耗（DB）	skew（ps）	损耗（DB）	skew（ps）	损耗（DB）
G1_NVHS3_G5_NVHS1_TX0_DN	8988.99	21.76	NA	21.09	NA	20.55	NA	26.04
G1_NVHS3_G5_NVHS1_TX0_DP	8988.99							
G1_NVHS3_G5_NVHS1_TX1_DN	9043.99	20.73	17.16	23.35	25.67	24.55	26.75	21.21
G1_NVHS3_G5_NVHS1_TX1_DP	9043.99							
G1_NVHS3_G5_NVHS1_TX2_DN	8969.79	20.8	17.16	28.28	31.91	29.61	32.34	21.26
G1_NVHS3_G5_NVHS1_TX2_DP	8969.79							
G1_NVHS3_G5_NVHS1_TX3_DN	8977.28	19.69	4.04	32.71	42.01	32.87	42.68	19.41
G1_NVHS3_G5_NVHS1_TX3_DP	8977.28							
G1_NVHS3_G5_NVHS1_TX4_DN	9519.81	18.62	7.42	18.82	3.53	18.89	3	31.08
G1_NVHS3_G5_NVHS1_TX4_DP	9520.05							
G1_NVHS3_G5_NVHS1_TX5_DN	9007.72	20.39	11.08	19.81	14.21	19.98	13.89	20.7
G1_NVHS3_G5_NVHS1_TX5_DP	9007.72							
G1_NVHS3_G5_NVHS1_TX6_DN	9036.04	20.43	13.72	19.99	9.21	19.73	9.64	40.05
G1_NVHS3_G5_NVHS1_TX6_DP	9036.04							
G1_NVHS3_G5_NVHS1_TX7_DN	8990.32	21.42	21.56	20.31	15.82	20.58	16.3	22.67
G1_NVHS3_G5_NVHS1_TX7_DP	8990.32							

Useful Method to degrade FiberWeave Skew

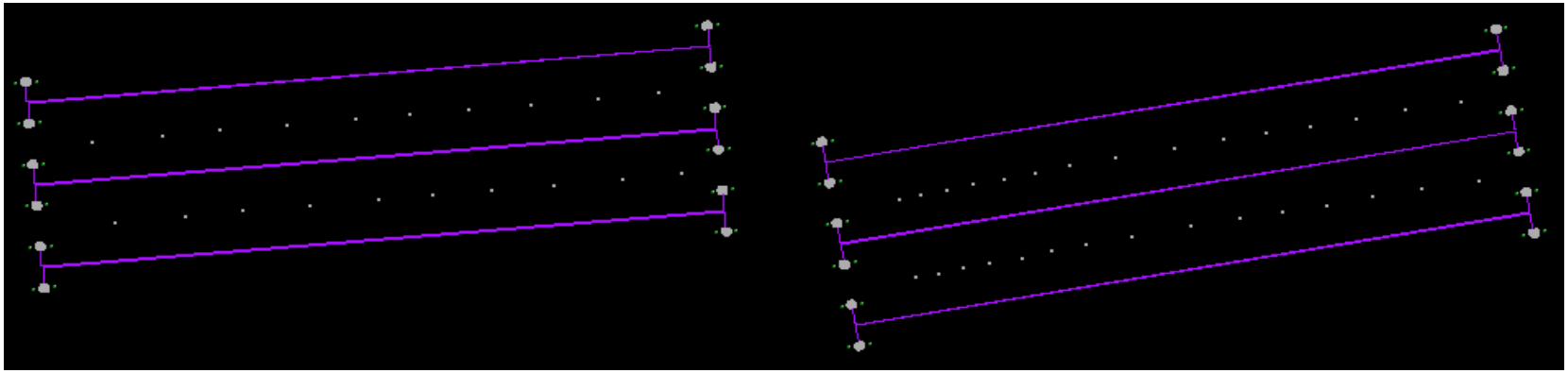
Item	Method	Description
1	Zig-Zag Routing	10 degree
2	**WorkPanel Rotate**	For 25G Serdes it`s better to rotate 10 degree.
3	Stackup design	Low window size pp and core
4	NE-Glass	Low yarn Dk
5	Diff Pitch same as yarn pitch	Warp or Fill direction
6	WorkPanel design fill direction	Low window

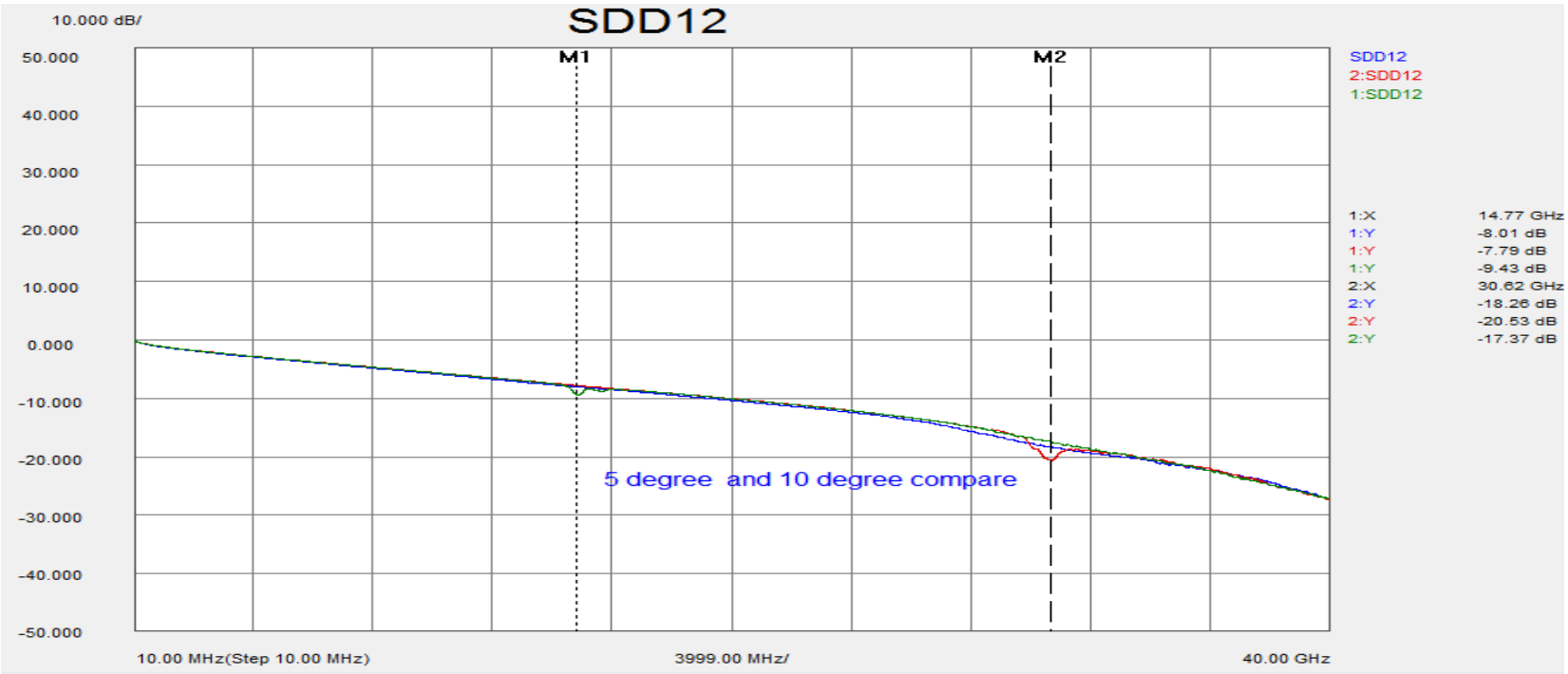


Glass	pitch
1035	15.2
1067	14.3
1078	18.5

L2 L3	Core(RTF/RTF)	1*3313	3.543(0.090)
	PP PP PP	PP(2116)RC53 PP(1080)RC68 PP(2116)RC53	13.063(0.332)
L4			

Glass angle resonance consideration





中科曙光
Sugon

谢谢！